Environments that Build the Future: Creating Sustainable and Stimulating Learning Spaces at East Washington Academy

An Honors Thesis (HONRS 499)

by

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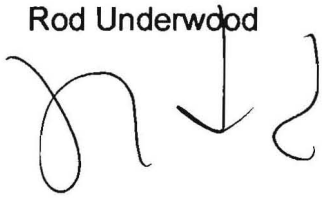

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Abstract

It's frequently said that children are our future, and yet we place them in some of the most uninspiring and educational-hindering environments called schools. How can society expect young children to stay motivated and focused when there is no stimulation and motivation to stay focused offered by the surrounding physical environment? School design is becoming an important field in architecture and interior design, as more and more studies are emerging which show the benefits of stimulating learning environments. This thesis is a case study of East Washington Academy, a K-5 grade school in Muncie, Indiana in regards to ways to make the building more sustainable and the environment more stimulating for the students. The elements and design changes are divided into three categories or stages, the first being smaller, less invasive changes, to the third category being large scale changes.

Acknowledgements

I would like to thank Professor Rod Underwood for all of his help in not only with this project, but through all the tough times in my four-year architectural education.

I would also like to thank Mr. Scott Blakely, principal of East Washington Academy, for letting me use his school as a case study and for being most helpful with any questions I had. I also extend my thanks to the teachers and students of East Washington Academy for taking the time to answer the surveys and letting me walk through and observe their school.

I also owe many thanks to my mother. She has been sounding board, editor, and a source of great strength and stability through this entire process.

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Author's Statement

Through my study of architecture and interior design over the past four years, school design has caught my interest. It is my belief that schools are the key to the future of our society. It is in these buildings and environments that students learn the skills that they must use in the future to succeed in society. If students do not learn these skills, they won't succeed, and I see that as a failure of the school.

There are two parts to a school: the instruction/teaching and the physical environment. East Washington Academy is excelling with the former. The teachers are very devoted to giving the students everything they need to succeed, from small group instruction to monthly, collaborative meetings between teachers. As it says on the school's website, the administration and teachers want to "allow every student to maximize his or her potential, and...possess the basic skills necessary to be a positive, productive contributing member of society."

The physical environment of East Washington Academy is not doing as well. The colors are dull, the artificial lighting is hard on the eyes, and the atmosphere can be noisy. It is difficult for children to learn in a non-stimulating, uncolorful, uninspiring space. Young children are naturally active, so to put elementary school students in spaces that require them to sit at a desk for hours goes against their natural inclinations. This is why I feel so strongly that as an architect and interior designer, I should strive to make classrooms and schools more welcoming, stimulating, and comfortable to work in.

East Washington Academy
1000 E. Walnut Street
Muncie, IN 47305

Introduction

East Washington Academy opened in 2009 and is home to 365 students, from kindergarten through 5th grade. This school focuses on small classes and making sure that every child is given as much help as he or she needs to succeed. While the school's philosophy and the drive of the staff are bent toward helping students succeed, the physical environment of the school is not. This project looks at ways to make the building more sustainable and the environment more stimulating for the students. The school is neither sustainable nor especially stimulating in its current state. The colors are neutral and unenergetic, rather the stimulating and encouraging students to stay focused during class. All of the classrooms rely on fluorescent lighting, which has been tied to visual strain and headaches (McColl, pg 255, 260).

The classroom area of the school is a square with the learning areas around the exterior, (Image 2). This layout is beneficial in that every classroom has an exterior wall for windows, though the current design does not take full advantage of this. The rooms are separated by moveable partitions, which allow classes to combine for activities if desired. Many of the walls do not fully extend to the ceiling, which leads to issues with noise. The teachers also noted that the walls are large and hard to move so they tend to leave the partition either open or closed and not change the position often.

Typical classroom at East Washington Academy

The entrance to every classroom is from a side that is open to the hall, except for six-foot tall, movable cabinets. While this openness creates a nice, welcoming space, noise is an issue again, from adjacent classrooms and people walking in the hall. The hallway is nice and wide, but lacking in color and decoration, rather than encouraging school spirit and learning.

Hallway at East Washington Academy

Teachers were surveyed about their physical teaching environment. Teachers were from all grade levels and from every area of the building. A copy of the survey can be found in the appendix. Due to school district and legal restrictions, students were not surveyed.

Stage 1 – The Little Things

Lighting

When asked if there was glare on the work surfaces in their classrooms that make it hard for students to work, the response varied by grade taught. The younger grade teachers reported that glare was not an issue, but as the grade level went up the issue with glare increased. This could possibly be attributed to the fact that as students get older they do more work at a desk and would be more likely to notice and be bothered by glare. Glare also seems to be tied to adequate lighting. Teachers that reported no issues with glare tended to answer that there was adequate lighting, whereas teachers that had large issues with glare didn't think there was enough lighting.

The research agrees with the teachers' responses. Many studies have been conducted and have all found that "inadequate lighting and glare...can seriously impact a student's ability to learn" (Evans, 65). Evans also states that the solution to glare is to control it or eliminate it by avoiding "overhead glare from sources above the work area" (66). In order to accomplish this, direct lighting, or fixtures that send most of their light downward like traditional fluorescent fixtures, must be avoided. When all the light is directed downward and the lamp of the fixture is exposed, the bright reflection of the lamp is often seen on the working surface creating visual discomfort. Direct lighting can also result in "slightly darkened walls and ceiling" (Grondzik, 570).

The simple solution would seem to be to use an indirect fixture, where 90 percent or more of the light is sent upward. These types of fixtures have "practically no veiling reflections [or] shadows" (Grondzik, 566), and there are fewer dark spaces due to the light being directed at and bouncing off the ceiling. Issues with indirect fixtures arise when seeing tasks, like reading, are attempted. Often an additional light source is needed. Indirect fixtures also give a relaxed, soft feeling to a space, which would be counterproductive when students are already acting sleepy, as teachers at East Washington Academy reported.

After considering all of these characteristics, I selected a semi-indirect fixture for the classrooms. With these fixtures 60 percent or more of the light is direct upward, and the rest is sent down like in a direct lighting fixture. Indirect lighting "[light] distribution is similar to that of indirect lighting, except it is more efficient" (Grondzik, 567). Since some of the light is directed down, seeing tasks become easier to accomplish without additional task lighting.

My selection was the Antera Light from Deco Lighting. It is a semi-direct fixture that will soften the fluorescent light in the classrooms, without compromising the ability to do intense visual tasks, like reading.

www.getdeco.com/products/architecturallighting

Fluorescent lamps are also a problem. One teacher even wrote on the survey, "Fluorescent lights are awful!" The statement is backed up by research. One study found that "fluorescent lighting increased hyperactivity among children,"(King, 10) and other studies linked fluorescents to causing "headaches, eyestrain, and other more serious health complaints,"(McColl, 255). To solve this problem, I suggest using full spectrum fluorescent lighting. These lamps simulate daylight so well that they have been found to "improve visibility, reduce hyperactivity in children, improve academic performance, and reduce fatigue," (McColl, 256).

Lighting control is also an important aspect to adequately lit rooms. A diagram of the switching zones is in the appendix (Image 4). The concept is that fixtures near windows are on separate switches from those far from windows. This way if it is a sunny day the lights near the window can be off, allowing the sun to light that part of the room without shutting off the fixtures across from the windows. Dimmers are also a key feature to have. Teachers can adjust light levels depending on the amount of daylight and/or the activity needs. Dimmers are also a way to save on energy costs, since the dimmer the light, the less energy is used.

Windows

Every teacher responded fully in favor of more daylight in the school. One teacher wrote in that he or she would add in skylights. Whether or not these teachers understand the benefit of natural light in a classroom is uncertain, but their responses show the innate human desire for sunlight.

The obvious advantages to daylight are that it enhances color and appearance, but there are many other benefits to daylight that are not as well known. Daylight "improves test scores, reduces off-task behaviors, and plays a significant role in student achievement" (Taylor, 130). A one year study conducted from 1999-2000 across three different elementary schools found that "students with the most daylighting in their classrooms progressed 20 percent faster on math tests and 26 percent faster on reading tests in one year than those students in with the least daylighting" (Oldroyd, 248). Another study performed nationally in 2003 "found that test scores rose by more than 20 percent in buildings with good daylighting...and the number of sick days also tends to go down when natural light is combined with improved air quality,"(Libby, 105).

This combination of lighting and air quality came up in the East Washington Academy surveys too. One third of the teachers wrote in that fresh air/operable windows would be greatly appreciated. Operable windows would allow for breezes to enter the classrooms, which helps to create better indoor air quality. Good indoor air quality reduces sick building syndrome, which comes from recirculating stale air and not allowing for any fresh air to enter the system. Symptoms of sick building syndrome, "include upper respiratory infections, irritated eyes, nose, and throat, nausea, dizziness, headaches, and fatigue,"(Taylor, 129) all of which distract students from learning and possibly cause them to stay home sick, consequently missing entire days of learning opportunities.

Another benefit to day lit classrooms is a decline in sleepy behavior. When answering the survey about whether their students acted sleepy or had trouble concentrating, teachers of younger students tended to respond yes, while the upper grade teachers answered closer to "no" on the scale. The teachers that reported sleepiness and attention wandering said it often happens early in the morning and after lunch. In the same studies on test scores, teachers were asked what they saw as the connection between the score jump and increased daylighting. The majority answered that students were less sleepy. One teacher is quoted as saying "I don't get sleepy behavior...Having all this light makes a huge difference,"(Libby, 101-102). When students are engaged and not fighting to stay awake, they absorb more information and therefore perform better on tests.

There are the critics of daylight that point to increase cost for glazing and to the fact that glazing has less insulation value than a full wall. In regards to the first argument, while glazing may have a high initial cost, the amount of money saved in energy bills balances out that initial cost. Daylight "provides these [energy and economic] savings during the day, when demand for electric power is at its peak and rates are at their highest" (Taylor, 39). As for insulating value, glazing manufacturers have made huge strides in new techniques and technologies, such as "high-efficiency windows and double-paned windows" (Taylor, 130) that can provide higher insulation values than regular glazing. Examples of schools that have been built on modest budgets that not only include daylighting techniques, but addition green/sustainable systems include, Clackamas High School, Dalles Middle School, and Ash Creek Intermediate School, all located near Portland, Oregon. These three schools that range from 265,355 sq. ft. to 59,000 sq. ft., were all built "on a very limited budgets – about $125 per square foot" (Libby, 134).

The redesign of East Washington Academy's classrooms takes all of this daylighting information into account. There are two different schemes that vary in the level of change/construction, but due to the large scale construction required for both designs, they are discussed in the third stage.

Color

The current overall color scheme at East Washington Academy is achromatic, a scheme that uses only neutral colors. Any color in the classrooms comes from decorations that teachers put up. While the teachers ranged from neutral to dissatisfied on the current colors, they all wanted to see more variety of colors and think the current scheme is too dull/monotonous and in some teachers' opinions too dark.

This is where color psychology comes into play. These colors that are currently in the school do nothing to stimulate students. White is associated with cleanliness, purity, and innocence, but is also considered to bring connotations of surrender, emptiness, and clinics (Reed, 28-29). Younger children do not fully comprehend what purity and innocence are, but they do understand feelings associated with hospitals. A hospital is usually white and 'clean-feeling,' and carries connotations of fear and anxiety. Students should be at ease in their classroom, not uptight and anxious.

Brown is a tricky color to work with. According to Reed, when there is brown that is reminiscent of wood in both color and texture, it has positive associations of home and nature. When the color and/or pattern are not wood-like, connotations tend to be more negative and include boredom, gloominess, and melancholy (29). These are again feelings students shouldn't have while in a place of learning.

Colors with a low saturation level, meaning they have a lot of grey added, tend to carry a feeling of melancholy and boredom. "As colors become less intense and lighter, the contrast factor diminishes and contrast for dominance is more difficult to attain" (Reed, 81). What Reed is saying is that less intense colors are dull and not stimulating to young children. Attention spans tend to be short in children, so in a school setting where focus is needed, color can help direct students' attention by giving dominance to one object, wall, or area in the classroom.

The color scheme and designs that I created for the classrooms create focal points on the main teaching wall and add in strong, vibrant colors to stimulate the eye and mind. (Image 11 & Rendering page 17) Focal points are to be used sparingly in rooms so that they "give the eyes a place for rest or contemplation" (Reed, 86). If the board or instructional wall is the focal point, then students' eyes will tend to rest there and pick up the information the teacher is showing. "The introduction of a vibrant [color] draws attention and emphasis" (Reed, 82), which is why the majority of the color is again on the focal, instructional wall. This is also why I chose horizontal stripes for the other walls. Stripes suggest movement, and that movement carries around the room to the instructional wall.

While red is the school color, it is known to elevate heart rates and blood pressure, especially when used in large amounts (Reed, 28). Given this I used red in the halls where students spend smaller amounts of their day, and only as accents in the room. The colors for the room stem from other beliefs in color psychology. Orange has been found to increase oxygen flow to the brain, which would be ideal for a learning

institution. Again this is a warm color and can increase a person's heart rate, so it is used in moderation in these rooms. To balance red and orange I selected a tetrad harmony and added in blue and green. These latter colors are attributed with lowering heart rates and a increasing a sense of calm in people.

There is still a lot of white or off-white in the design, but that is for the benefit of reflecting light deeper into the room. Also when a light neutral is offset with vibrant, saturated colors it doesn't seem as dull and cold as it does up against other neutrals because there is a sense of hierarchy and focus.

Furnishings

Single desks with plastic chairs currently furnish the classrooms. These do offer some flexibility for different room formations, but two-thirds of teachers answered in the survey that they would prefer movable tables and chairs for their classrooms. This response came from all grade levels.

Research on how the mind learns has changed, and it doesn't support the old classroom model with the teacher at the front of the room and all the students at desks set in rows. Compared to 30 years ago, "today's kids are more interactive and mobile and need furniture to accommodate and encourage their productivity,"(Peck, 1). Both teachers and designers are realizing this and are working to "provide different configurations for learning environments, more flexibility, adaptability, movable components, and future conversion to other uses" (Taylor, 11).

This is the reason behind my selection for moveable furnishings. I also selected tables and chairs that are adjustable and ergonomically designed for the most comfort; after all students can spend close to 6 hours a day sitting. "Modern, ergonomic, flexible," furnishings are listed by Taylor as "a high-performing element" (131) for well-designed, sustainable schools. Tables were selected, as opposed to individual desks, because as Peck writes, "Tables take away the temptation to mess with all the little goodies and gadgets kids seem to stash in that compartment under their desks" (1).

My selection for the seating in the classrooms is the Prodigy Series Z-Leg School Chair from Artco-Bell. They are designed to rock slightly so the person can find the most comfortable angle. They are plastic which serves as a two-fold benefit: they are durable and light so they can be easily moved. The ability to move and stack the chairs easily was a selection criterion so that classes can move the furnishings if a large activity space is needed. The color could be red, blue, or green, or a variety of all three.

artcobell.com

The table is from Dallas Midwest. It is the Adjustable Height Blow Molded Computer Table and is 48" x 24". The height is adjustable. I decided on the mocha granite color since it was a neutral that wouldn't distract from any of the work students have on the desk, though the table is available in red, blue, and green if the school would prefer one of those colors instead.

www.dallasmidwest.com

In response to the survey question to draw the ideal classroom layout, one of the teachers added a countertop. This idea struck me because a countertop can be seen as wasting space under it, unless the space is used as storage. Storage is the key because without desks, students would need a place to store supplies, books, and other odds and ends. This gave rise to the idea of using half lockers or cubbies. The top of the lockers can serve as a countertop, while student storage is provided.

The lockers I chose are from Jonti-Craft. These Sproutz Stackable Lockers are 100% recycled wood fiber and are 48" x 15". A single stack is 23.5" high and a double stack is 44" tall.

www.schooloutfitters.com

Board Space

Three teachers listed another white board or more board space in the final question of the survey as something they would add. An additional small whiteboard on a track in front of the existing board could be added to expand the writing surface area. This way the daily schedule could be on one end, and when it was time for math, the additional piece could slide over the schedule and create a full, clear whiteboard. (Image 8)

www.schooloutfitters.com

I think more display space would be most useful in the hall. This would provide areas for classes to display work that other students can stop and admire. "Displays [that are] student based and museum-quality galleries" (Taylor, 131) are important to a high performing school. This is because being able to see work done by other students creates a sense of community through sharing a glimpse of what that class is doing. It also creates a sense of life in the halls, because it can change easily and frequently.

Community Garden

One teacher specifically put down "more plants" as something he would change/add to the school. This is a great idea that I propose to take farther and to create a community garden that the students could work in, the community could help with, and the produce could be sold to the community. Community access is another of Taylor's "high-performing elements" (pg 131). A garden gives students the opportunity to learn patience, problem solving, healthy eating, and biology all at the same time. Studies also show that gardening improves students' academic skills because the gardens offer places students can "translate sometimes dry academic subjects into practical, real world experiences" (*Gardening in School*).

Pulling the community in is not only a way for students to learn from their elders, it's a way to create a stronger sense of community. By interacting with the students and getting to know them, members of the community create a bond with these children and in a sense become another guardian of them. "Great schools...recogniz[e] nature and the city as extensions of the learning space...this is an ecologically sustainable model at its broadest level, involving a system of relationships that expand the boundaries between living, learning, and working" (Taylor 16).

Courtesy of the Impact Lab
www.impactlab.net/2010/07/09/gardening-in-school-boosts-child-development

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Stage 2 – Structural Changes

Wall Between Classrooms

On the surveys, roughly three-fourths of the teachers reported that students were distracted during class by noises. Responses included noise from people in the hall, noise from the HVAC system, and noise from adjacent classrooms, especially since the walls do not extend all the way to the ceiling in some cases. This issue of noise is an important one to solve. "Students do not learn when they cannot hear well, and noise causes stress" (Taylor, 128).

My design solution is two-fold. The first part is to fill in the low walls, either with double pane glass or concrete masonry units (CMU's) if the cost of the glass is too much. Glazing is my primary selection though because it allows for light to transfer between the areas, and it still gives a sense of openness. I like the idea of being able to open up a wall and connect two classrooms, as do the teachers, which is why I am not proposing to create a solid wall between the rooms. I wanted to make it easier though than dealing with the current floor-to-ceiling folding doors. My design uses sliding doors or pivot doors that can easily be moved to divide the classrooms or connect them. The opening would still be large enough to give a sense of connection since there are two doors, both four feet wide, which equals and opening of eight feet when both doors are opened.

www.acousticalsolutions.com

The panels I selected are EcoSorpt Recycled Cotton Wall Panels from Acoustical Solutions Inc. These panels are 100 percent recyclable and made of 85 percent post-industrial recycled content. The panels come in 2' x 4' and 4' x 8'. I also selected the light grey. This way color could be added later to match the classroom scheme.

The second half is to create a sound barrier to the hallway. The design does this by dropping a set of acoustic panels from the ceiling so that noise from the hall will stay out of the classroom space without fully closing off the currently open space between classroom and hall. (Image 9)

Extensive Green Roof

The current roof of the school is flat and black. A flat roof presents problems with rainwater because if the drainage fails or the water proof barrier breaks, rainwater will pool, verses a sloped roof, where water will drain due to gravity. The issue that arises from the use of black as a roof color is that it adds to the heat island effect. The heat island effect is when the area around a dark surface is actually hotter than the real temperature. It's why on a sunny summer day it is hotter on asphalt than on grass. The black colored roof on the school absorbs the heat and some of that heat is transferred into school, raising cooling costs.

To address all of these issues, I am proposing an extensive sedum green roof. American Hydrotech is a green roofing company from Chicago that has been manufacturing and installing sustainable roofs since 1997. The Extensive Garden Roof is ideal for East Washington Academy. The plants for this roof come from a "range of hardy plants, making it attractive to look at while requiring little maintenance," and they "process airborne toxins and re-oxygenate the air" (*Garden Roof*).

As far as dealing with the issues the current roof at East Washington presents, any green roof system helps with storm water management. According to Hydrotech's website, an Extensive Garden Roof can retain 50-90 percent of the water from a typical

rainfall, and since only plants native to the area are used, they can withstand periods of drought. Green roofs also help to reduce the heat island effect since the plants absorb the sunlight and convert it to energy rather than sending it back out into the surrounding air, reducing the cooling load of the school.

The reason I selected an extensive, not accessible green roof is simple. An extensive roof requires very little growing medium, 4 inches maximum, versus intensive, accessible roofs that require much deeper amounts of soil. Installing a green roof on East Washington Academy would be a retro fit, so the less additional structure that needs to be added the better. The Extensive Garden Roof "is very light, weighing little more than a traditional ballast roof, allowing for safe installation on almost any existing roof" (*Garden Roof*). An accessible, intensive roof with large plants and trees would be possible, but would require reinforcing structure and much more time, money, and energy, with little additional value.

Extensive Garden Roof System
Courtesy of American Hydrotech

California Academy of Sciences – Extensive Garden Roof done by Hydrotech
Courtesy of American Hydrotech

Stage 3 – Large Structural Changes

Additional Windows

I have created two redesigns for East Washington Academy's classrooms with regards to the windows. Both designs keep the two existing windows in each classroom, but make them operable for fresh air. One scheme adds clerestory windows above the existing white boards to let daylight penetrate into the room. Even if the windows are only 2 feet high, the addition of a light shelf would help extend the light into the room (Images 6.1-6.3).

The second design is on a larger scale. This design calls for moving the board from the current window wall and placing it on a side wall. Then more vertical windows will be

added that pick up on the current window size. These tall windows allow the light to travel farther into the room. All the windows would be operable and also have pull-down shades so that teachers can regulate how much light they want in their classroom. (Images 7.1-7.3)

Since the classrooms are almost 40 feet deep, the windows on the far walls will not bring the light all the way into the classroom. I have proposed two additions to help even the daylight levels out. One is the addition of roof monitors, and the other is skylights in the hallway.

Roof Monitors

The monitors I designed for East Washington Academy face north. This allows the less intense northern light in and provides an ideal southern slope for photovoltaic and solar hot water heater arrays.(Image 10) Monitors have proven to be great sources of daylight for spaces in many case studies. Enough light is usually provided to "enable the electric lighting to be off most of the day, reducing cooling [needs]"(Guyon, 34). Blinds can also be added to the inside of the glass so that teachers can fully darken the room if they so choose.

The problem with designing monitors for East Washington Academy comes from the design being a retro-fit. There is a strong chance that the openings for the monitors will fall across structural joists and/or beams in the ceiling. The design solution is to encase any of these in dry wall and turn them into part of the light diffusing system.

Skylights in the Hallways

The design of skylights in the hall has two purposes, to bring in more natural light, reducing the need for electricity, and to define a separate, different space from the classrooms. The skylights are five feet wide so that light will reach two-and-a-half times as far into the space as the width of a roof opening. (12'/2.5 = 4.8' → 5') The openings are ten feet long so that there is a nice proportion between length and width that brings in 50 square feet worth of daylight.

I decided on a skylight that is a barrel arch. The skylight would be made out of extruded plexi-glass so there would be fewer joints than if the skylight was triangular. Fewer joints means there is less chance of leaks developing. The repeating openings in the ceiling create a continuous rhythm and movement down the hallway, which differentiates it from the classrooms that branch off.

The addition of skylights eliminates much of the current hall lighting, so I selected a new light fixture. The EGLO 87307 Santiago 1 wall sconce is the perfect balance of fun and function. The sconces are placed every 10 feet along the halls. Each fixture is one foot by one foot and can hold two 40 watt incandescent bulbs.

www.eglo.com/index.php/international

With two 8 watt compact fluorescent bulbs, one fixture gives off 16 footcandles (see calculation below). With the addition of the skylight, the 16 footcandles is plenty to light a hallway. Chances are the hall lights could be off most of the time due to the light from the skylights, which is why I suggest having the sconces on daylight sensors so they only turn on when needed.

8 watts x 2 bulbs = 16 watts
16 watts x 80 lumens/watt (for fluorescents) = 1280 lumens
10 feet x 8 feet = 80 sq ft (distance between sconces x width of the hall)
1280 lumens / 80 sq ft = 16 footcandles.

Renewable Energy - Geothermal heating/cooling, Wind power, Solar energy (Image 1)

"Renewable energy...can significantly reduce a school's operating costs" (Evans, 57). That should be enough to explain why a school should use renewable energy, but there are other reasons too. These techniques and systems offer more practical, hands-on learning opportunities for students. Geothermal, wind, and solar energies "are exciting technologies that can be used to teach students about science, ecology, and the environment" (Evans, 57).

Spirit Lake's wind turbine (Evans, 57)

Money is of course always an issue, and initial costs for many of these systems may seem daunting, but the systems pay for themselves in just a few years. Spirit Elementary School, in Spirit Lake, Iowa installed a single horizontal wind turbine in 1993. For the first seven years after the installation, the school paid a total of $568 to the utility company for power. "The final payment...on the turbine was made in the 1998 fiscal year. Today, $25,000 per year in savings go to the school's instructional programs" (Evans, 59).

There have been complaints of noise with the horizontal turbines, so I selected a vertical turbine for East Washington Academy. Students need a quiet place to learn, and the school is in a residential neighborhood so noise reduction is a high priority. The Urban Green Energy UGE-4K fulfills this requirement. According to specifications on the UGE website, the turbine is "low RPM...they are virtually silent...and cannot be heard over a typical AC unit." The helical design also leads to lower vibrations, so the turbines can also be roof mounted. I would discourage roof mounted turbines at East

Washington Academy due to the amount of structural reinforcing need to carry the weight of the turbine.

This turbine is rated at 10kW, so a single turbine would not come close to fulfilling all of the school's electrical needs. The turbine used in Spirit Lake, Iowa was rated at 250kW, hence the larger amount of energy. A turbine rated that high is usually 200 feet tall and has a rotor diameter of 93.5 feet (*Wind Turbine Technology*). That is too large for any urban area. This discrepancy between the UGE-4K's power output and a school's energy needs can be met by adding multiple turbines and/or supplementing the wind power with other renewable energy such as solar.

The UGE-4K vertical wind turbine
www.urbangreenenergy.com/products/uge-4k

The UGE-4K as a roof mounted turbine
www.urbangreenenergy.com/products/uge-4k

My proposal for harnessing solar energy involves photovoltaic panels for electricity and solar hot water heaters. Both types of arrays are located facing south on the slope of the roof monitors. Additional arrays can also be added as stand-alone structures on the roof. (Image 10) For the photovoltaic panels I selected a multi-crystalline panel. These are slightly less expensive, but still provide a large amount of power. The panels I selected are from Suntech. The STP280-24/Vd is rated for 280 watts on the perfect sunny day and are roughly five feet by three feet. The same line also has 205 watt and 225 watt rated panels, the difference being price. The more expensive the panel, the more power it produces. The panels I picked also perform well in 'weak light,' such as cloudy days, mornings, and evenings.

The design has the photovoltaic panels tied to the electric grid. This means the system doesn't need an in-house battery. When the panels are producing electricity during off-times, such as the weekends, the electricity will be sold to the gird. During peak times, if the panels are not producing enough electricity, the school can pull energy from the grid. Thus the school becomes a mini power plant that does business in the grid. Buildings using photovoltaic panels find the electric bill greatly reduced, sometimes breaking even or even turning a profit.

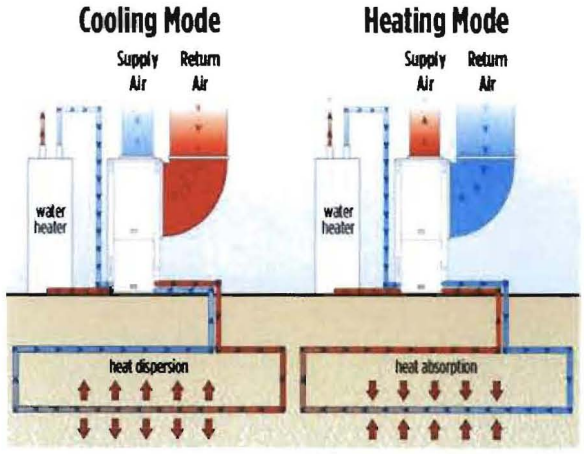
STP280-24/Vd Photovoltaic Panel
am.suntech-power.com/index.php

The solar hot water heater I chose is from Silicon Solar and is an evacuated tube, drainback system. The drainback system is ideal for two reasons. First, it does not use antifreeze like closed-loop systems. Second, the water will always drain out of the tubes so there is no liquid left that could freeze in cold weather (Grondzik, 931). This particular system is called the 80-120 Gallon System, meaning the tank can process 80-120 gallons of hot water in a day. Since the hot water would mainly be used for hot water in the bathrooms, I feel one would be plenty. If the school wanted to be ambitious, a second system could be added to take care of cafeteria and kitchen needs.

80-120 Gallon System
Evacuated tube, drainback solar hot water heater
solarhotwater.siliconsolar.com/solar-hot-water-products.php

Geothermal heating/cooling is another renewable energy that could be harnessed. The basic idea behind this system is that just a few feet down the earth stays a constant temperature. Fluid is run through piping buried in the ground, into the building, and back out in a closed loop. During the winter the warmth from the ground is picked up by the fluid in the pipes, and is carried into the building where the warmth of the fluid is used to heat the building. The now cold air returns underground to be rewarmed. In warm weather, the concept is reversed. Warm air from the building is transferred to the fluid, which dumps the heat into the cooler earth (Grondzik, 362-362).

The underground piping for the system can be horizontal or vertical. I recommend horizontal since it is less expensive to dig only down six feet rather than 150 feet, and East Washington Academy has enough land to install horizontal piping. There are two options for heating and cooling the building. The first is to retrofit all the floors for radiant heating. With this scenario, when the fluid returns from the underground pipes it is immediately sent through other pipes under the subfloor. The heat is then transferred up into the space. The second option involves pumping the fluid through an HVAC unit and is used to heat or cool the air being pumped through the ducts. I would like to the see the radiant floor system installed, especially since East Washington is all on one level, but that would involve a lot of extra construction and remodeling, so I would recommend the second option of an air exchange system.



Geothermal heating and cooling with air exchange
Courtesy of: David White Services
www.davidwhiteservices.com/images/Geothermal-simple.jpg

Conclusion

There are many ways that East Washington Academy could improve the physical environment of their building to increase its sustainability and stimulation. The improvements and changes vary in scale and amount of construction needed. These design proposals range from changing paint color and types of furniture to constructing skylights and monitors in the ceilings of the hallways and classrooms.

These changes provide stimulation through color and daylight. They can improve student performance by making it easier to concentrate through noise reduction, increased daylight, and decreasing glare on work surfaces. Chances for students to be exposed to practical applications of their studies through science in the community gardens and technology through the alternative, green energy systems also come from these design improvements.

Ultimately it is up to the school to decide how many of these changes and improvements to implement. Any of these design changes will help to create a more stimulating and sustainable environment. After all, schools are where our future is educated, so shouldn't they offer the best possible environment to work in?

Rendering of classroom with proposed design changes.

Rendering of hallway with proposed design changes.

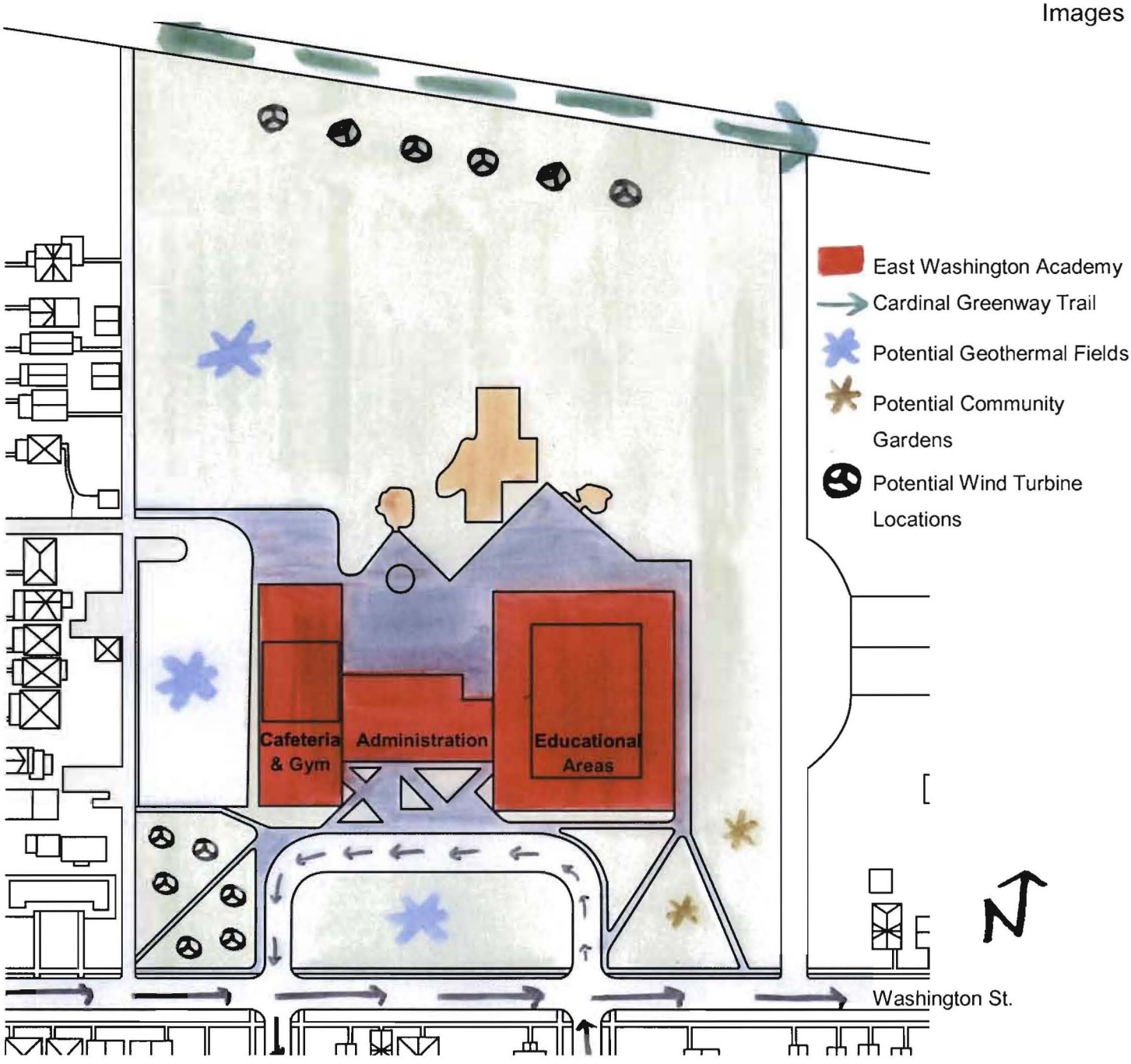


IMAGE 1 – Site Plan

The proposed locations for the geothermal fields are under the field, parking lot, and front lawn. These are areas where there is a lot of land with nothing underneath like foundations or tree roots. Also if something was to happen to the pipes, maintenance could be completed without disrupting daily activity too much.

The community gardens are placed in the front of the school to serve as a tie between the surrounding residences and the school.

Wind turbine location could be in two areas. If the school wants to show off their use of green energy, the turbines could be in the front. The second location in the rear of the site would be ideal if the neighborhood is worried about the look and noise of the turbines.

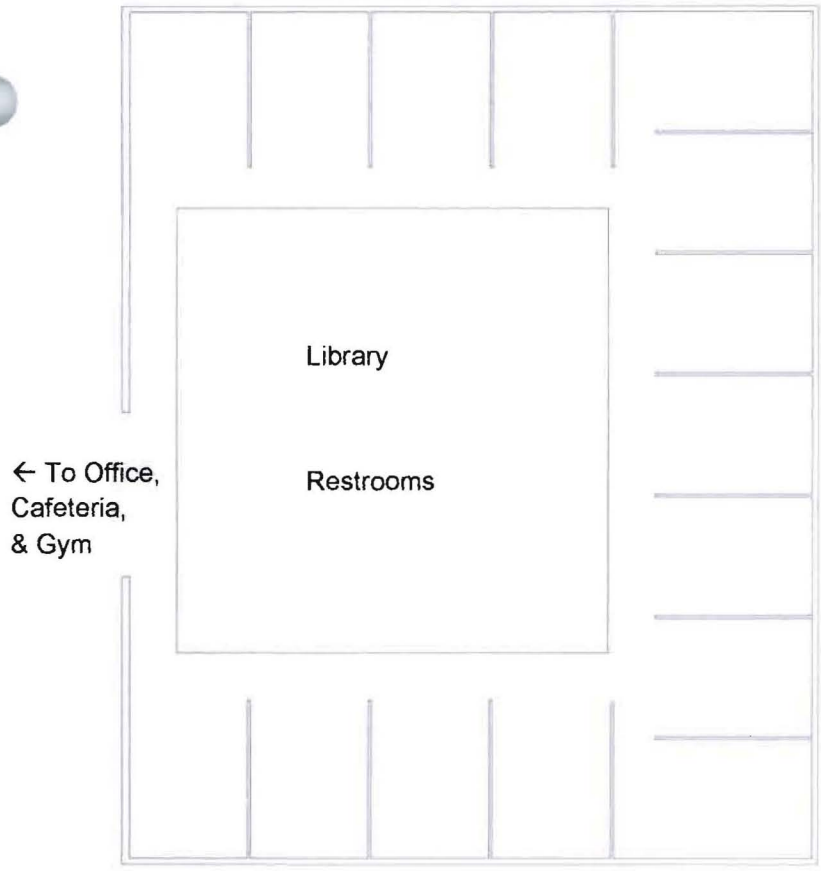


IMAGE 2 – Existing Classroom Layout

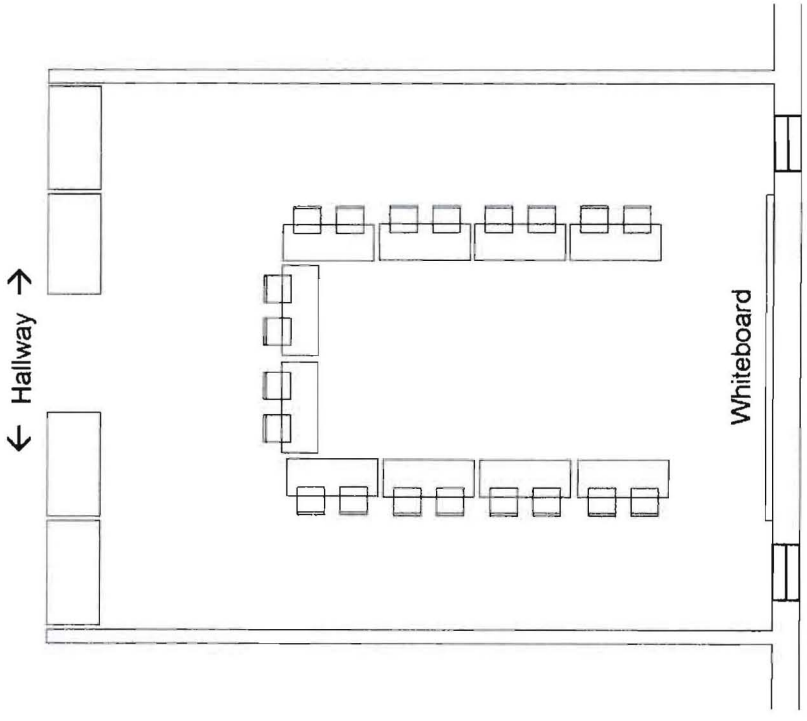
The classroom section of East Washington Academy has the rooms laid out around the edge of the building. Each classroom has one exterior wall that has two windows in it (see Image 3). Even the corner classrooms that have two exterior walls only have openings on the shorter wall.

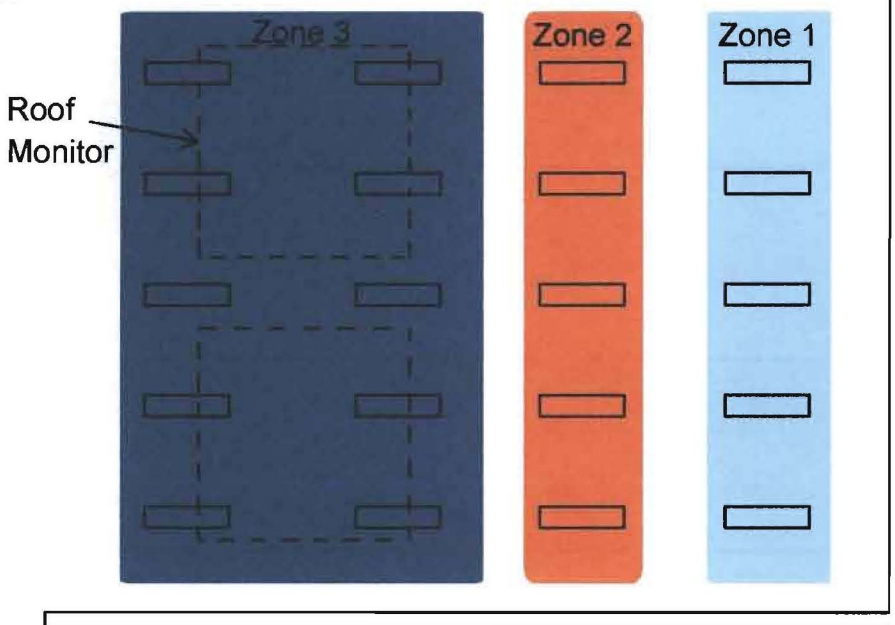
The library is at the center of the square, since it is a common educational area for the all the students.

The direct opening of the classrooms into the hall allows a lot of noise to enter the learning spaces, often distracting the students.

IMAGE 3 – Existing Classroom Plan

The existing classroom layout has the whiteboard mounted between two tall, narrow windows. The only division between the hall and the classroom space are four 6-feet tall, metal cabinets.





With this switching design it is possible to comfortably light the entire space while taking into account windows. All lights are also on dimmers to offer even more control.

IMAGE 4 – Switching Zones

Zone 1: Closest to the exterior wall & windows, so the majority of the time these lights can be off or at least on very dim.

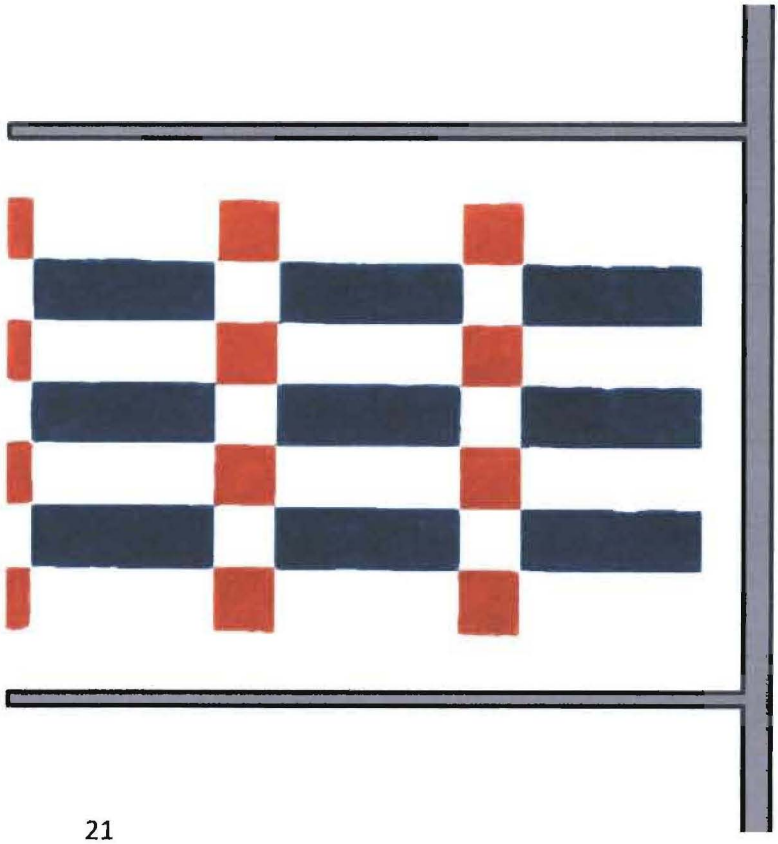
Zone 2: Lighting middle of the room. On sunny days there will be enough light that these aren't needed, but on cloudier days these lights can be on, while zone 1 can still remain off.

Zone 3: Lights under the monitors. This arrangement allows the teachers to control the artificial light depending on the amount of daylight coming in through the roof.

IMAGE 5 – Floor Design

This design uses carpet squares because if an area is ruined or gets worn down, it is easily replaced without having to remove the entire carpeted area.

I feel the use of a lighter color in part of design is fine, even though it is for a classroom. The nap of the carpet will be low so dirt will not sink down into the nap, making the carpet easy to clean. Since students have to walk through a good portion of the halls to reach their rooms, dirt from their shoes will have mostly worn off in the halls.



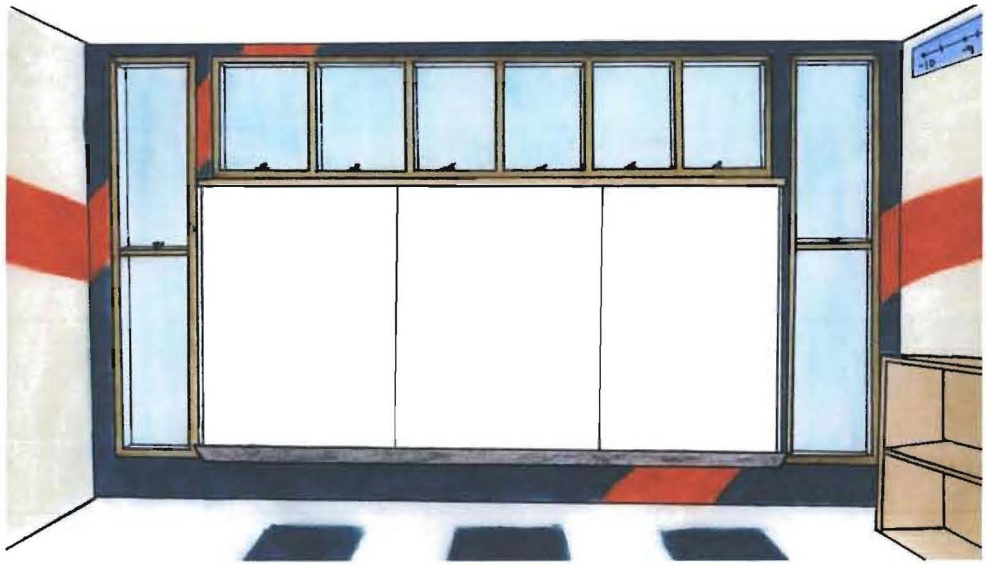


IMAGE 6.1 – Clerestory Window Wall

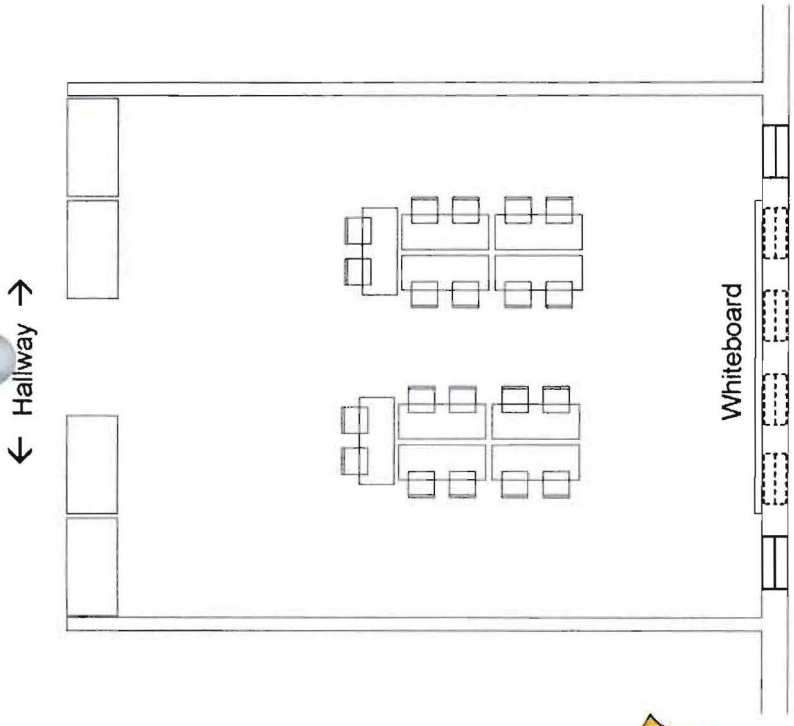


IMAGE 6.2 – Clerestory Window Plan

Clerestory windows added in above the existing whiteboards bring in more daylight.

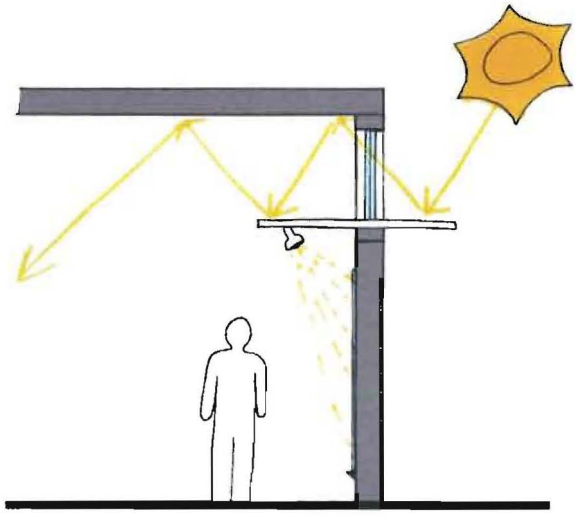


IMAGE 6.3 – Clerestory Window Section

Light shelves extend the sunlight deeper into the classroom space.

Since the light shelf overhangs the whiteboard, additional lighting could be added on the underside of the shelf.

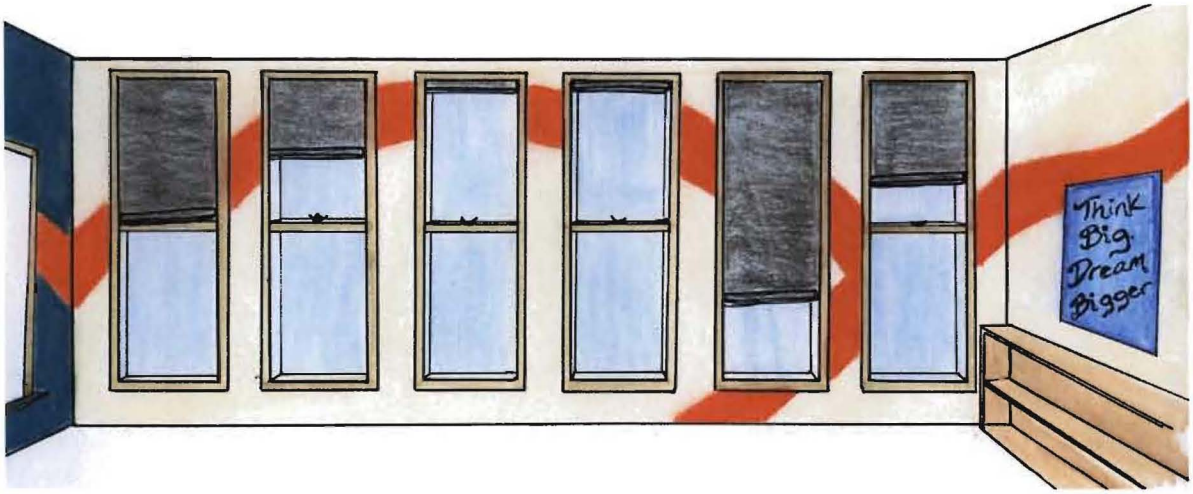


IMAGE 7.1 –
Full Window Wall

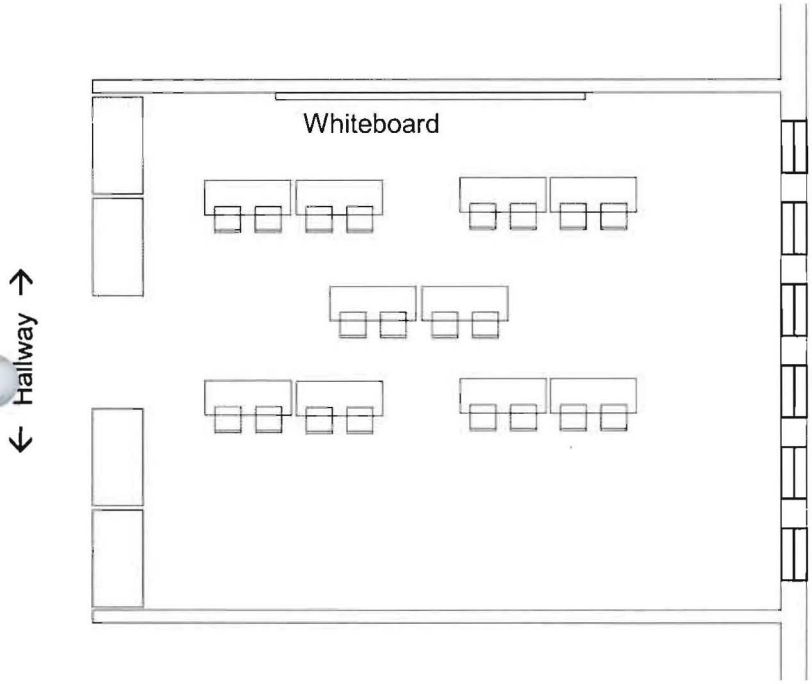


IMAGE 7.2 – Full Window Wall Plan

This design moves the instructional wall to one of the adjacent walls so that full windows can be added to the exterior wall. The full window allows the light to penetrate farther into the classroom.

Each window would have a semi-transparent shade that the teacher could adjust depending on the amount of sunlight and glare occurring. This way the semi-transparent shade filters bright sunlight, eliminating possible glare on the work surfaces.

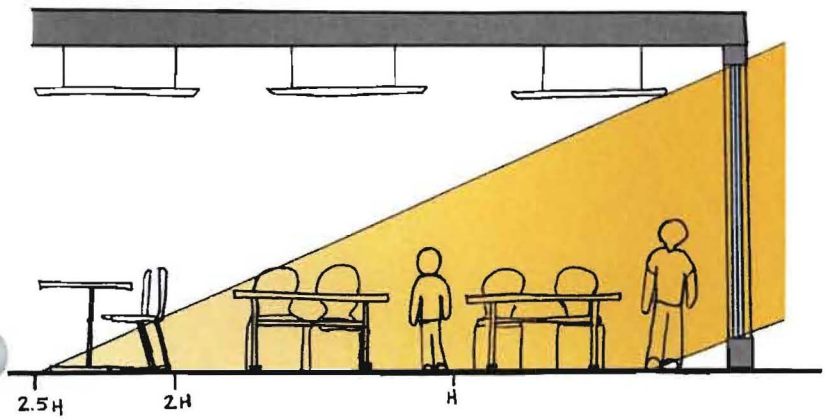


IMAGE 7.3 – Full Window Wall Section

Daylight will enter a room 2.5 times the vertical opening of the window (H). These windows are designed to be 10 feet tall, allowing the daylight to enter 25 feet into the room.

The farther the light goes into a room, the weaker it gets and the lower it falls. The most usable light is up to H. H-2H needs supplemental artificial light. 2H-2.5H is more of an ambient light level than a task lighting level. This influences the switching zones – Image 4.

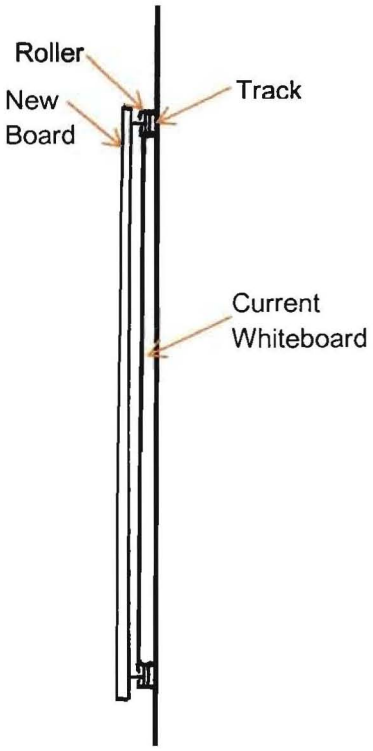
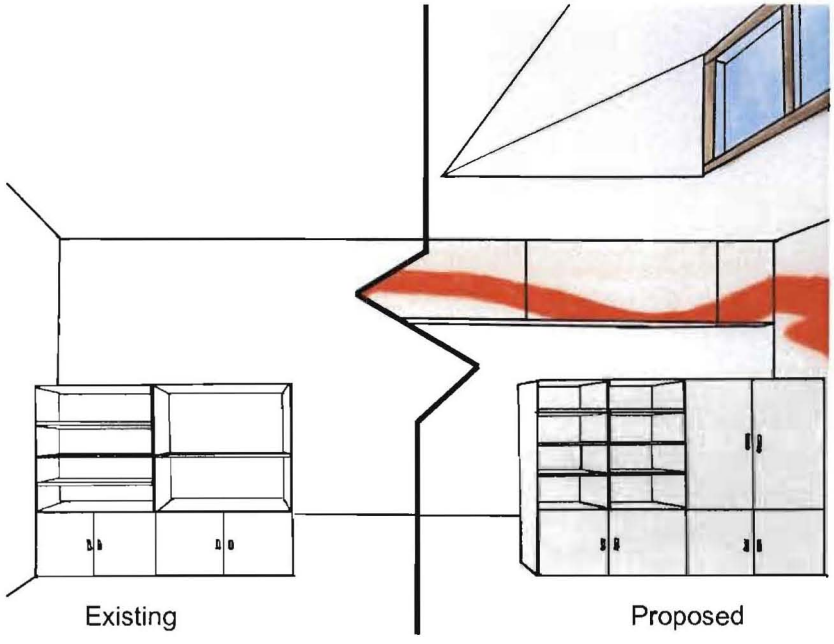


IMAGE 8 – Additional Whiteboard

An additional, sliding whiteboard would give the teachers the extra space they wanted without much work. Horizontal tracks would be added above and below the existing board. The new board would be mounted on rollers that set in these tracks allowing the board to slide side to side.

IMAGE 9 – Acoustical Panels

The proposal of acoustical panels is a means for decreasing the amount of noise entering and exiting the classroom. The panels decrease the amount of open space and will absorb the sounds from the classroom before it enters the hall and reflects into other classrooms. Since the amount of space open to hall is diminished the noise from the hall has less space to enter in and distract the students.



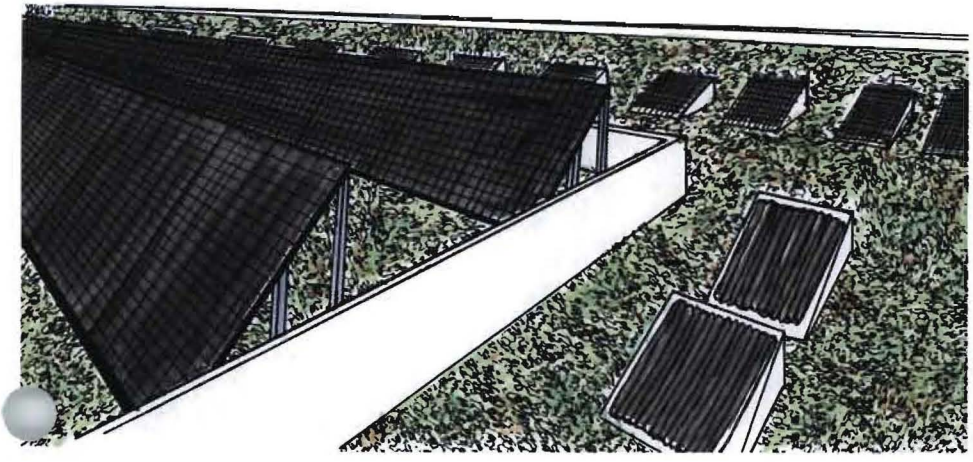


IMAGE 10 – Alternative Energy Roof Arrays

A sketch of the roof with the classroom monitors. There are stand-alone photovoltaic arrays, as well as solar hot water heaters and photovoltaic panels mounted on the backs of the roof monitors.

The roof is also covered in an extensive sedum roof to help with storm water runoff and to reduce the heat island effect.

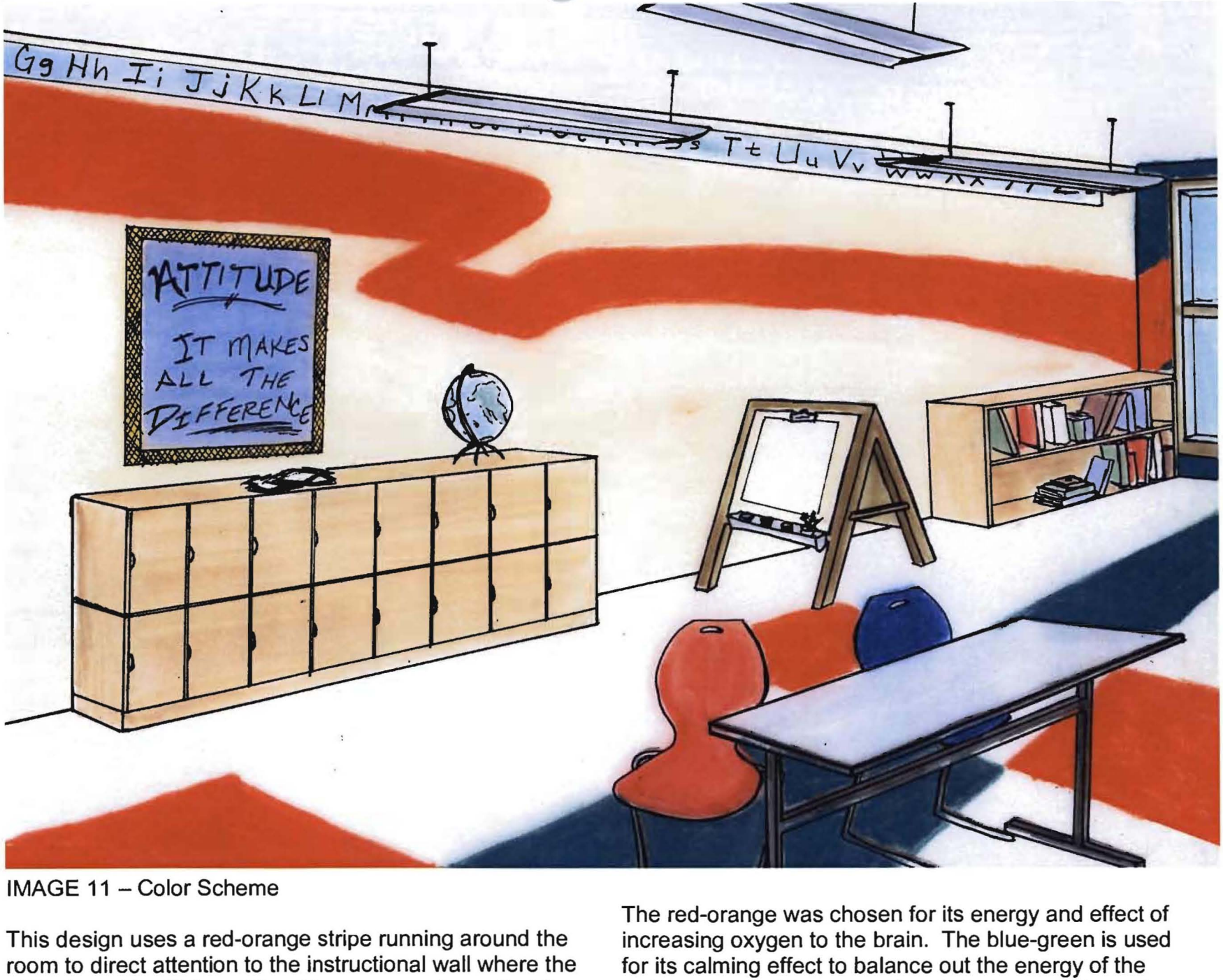


IMAGE 11 – Color Scheme

This design uses a red-orange stripe running around the room to direct attention to the instructional wall where the white board is. This wall is a blue-green color so that it stands out from the other walls and becomes a focal point.

The red-orange was chosen for its energy and effect of increasing oxygen to the brain. The blue-green is used for its calming effect to balance out the energy of the red-orange, and to ensure the students are calm and focused on the board.

My name is Sara Reich. I am a senior at Ball State University studying architecture and interior design. I am currently working on my Honors Thesis, which is looking at the design of schools, and I am using East Washington Academy as a case study. I would greatly appreciate if you could take a few minutes to complete this survey regarding the current environment of the school. If you don't feel comfortable answering one of the questions, feel free to leave it blank. Thank you so much for your time. Please feel free to add any comments that you wish or anything you feel I might find useful.

Grade Taught: _____

	Not at all				Yes, very much
Overall do you like the physical environment of East Washington?	1	2	3	4	5
Do you find the building noisy?	1	2	3	4	5
Too loud to concentrate?	1	2	3	4	5
Do you find the students getting sleepy during the day?	1	2	3	4	5
If so, when? (ex: after lunch, 2pm, morning)					
Do you feel students have trouble concentrating?	1	2	3	4	5
If so, when? (ex: after lunch, 2pm, morning)					
Do you find the school thermally comfortable?	1	2	3	4	5
(ex: not too hot or too cold)					
Are there issues with glare on the work surfaces?	1	2	3	4	5
Is there adequate lighting in the classroom areas?	1	2	3	4	5
Would you like to see more daylight in the school?	1	2	3	4	5

Would you like to see more variety of colors in the school? 1 2 3 4 5

Are you satisfied with the colors in the school? 1 2 3 4 5

(ex: on the walls and floor)

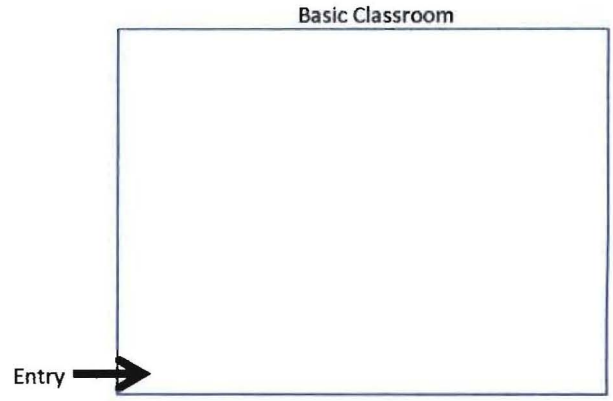
If you are dissatisfied with the colors please answer why. Circle all that apply.

Too dark Too light/bright Too dull/monotonous Just don't like the colors Other (please specify)

What distracts children from the lessons? (ex: people walking by, noise)

How could the physical set up and layout of your classroom change to better serve your teaching needs?

(Write, sketch or both)



Are you satisfied with the furnishings in your teaching space? Please explain.

What do you feel are the best seating options for the students? (circle choice)

Desks Movable table and chairs Other (please specify)

If you could have 2 things changed or added physically to the facility, what would they be?

Thank you for your time!

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